International Research Center for Elements Science
- Advanced Solid State Chemistry -

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Visitor

Prof ATTFIELD, John Paul University of Edinburg, UK, 1 July - 31 March 2005

Scope of Research

Novel inorganic materials and devices that have new, useful or exotic features such as superconductivity, ferromagnetism and quantum spin ground state are synthesized and fabricated by novel methods. For example:

- Oxides containing transition-metal ions in unusually high-valence state.
- Nonequilibrium materials that can be obtained by high pressure method or epitaxial thin film deposition method.
- Inorganic nanomaterials with useful functionality such as superparamagnetism and quantum size effect.

Research Activities (Year 2005)

Presentations

High-pressure Synthesis of a New Ferromagnetic Ferroelectric Material Bi_2NiMnO_6, Takata K, Azuma M, Saito T, Shimakawa Y, Takano M, 60th Annual Meeting, The Physical Society of Japan, 24 - 27 March (Tokyo).

Synthesis of Monodisperse, Submicron-Sized Spherical V_2O_5 Particles, Yamamoto S, Shimakawa Y, Takano M, MRS Spring Meeting 2005, 28 March - 1 April (San Francisco CA).

Synthesis of Ferromagnetic, Ferroelectric Bismuth Double-perovskite, Takata K, Azuma M, Saito T, Shimakawa Y, Takano M, 97th Sprig Meeting, The Japan Society of Powder and Powder Metallurgy, 1 - 3 June (Tokyo).

Synthesis and Magnetic Characterization of $L1_0$-FePt Nanocrystals Dispersed in Solvent, Yamamoto S, Morimoto M, Ono T, Takano M, 50th Magnetism and Magnetic Materials Conference, 30 October - 3 November (San Yose CA).

Single Crystal Growth of a Layered Cobalt Oxide $(Sr,Ba)Co_6O_{11}$ under High Pressure, and Its Magnetism, Saito T, Takeda Y, Ishiwata S, Shimakawa Y, Takano M, The 46th Annual High Pessure Conference of Japan, 31 October, Muroran Institute of Technology.

Designed New Ferroelectric, Ferromagnetic Materials -Bi_2NiMnO_6 and Bi_2CoMnO_6-, Takata K, Azuma M, Shimakawa Y, Takano M, MRS Fall Meeting 2005, 28 November - 1 December (Boston MA).

Grant

Takano M, Chemistry and Physics of 3d Transition Metal Oxides Equipped with Deep 3d Levels: Search for New Materials and New Functions, Grant-in-Aid for Scientific Research (S), 1 April 2005 - 31 March 2010.

Awards

Takano M, The L'Oreal Art & Science of Color Prizes: The 8th Gold Prize, Microstructure and Formation Process of the Characteristic Reddish Color Pattern "Hidasuki" on Bizen Stoneware: Reactions Involving Rice Straw, The L'Oreal Art & Science Foundation, 21 October 2005.

Saito T, Encouragement Prize of the Japan Society of High Pressure Science and Technology, Search of Transi-

Topics

Blue-Light Emission at Room Temperature from Ar^{+}-irradiated $SrTiO_3$

Oxide-based electronic devices are expected to have fascinating properties, unlike those of conventional semiconductors. Perovskite structure transition-metal oxides are key materials for this new field of electronics. Among them, $SrTiO_3$ is of particular important from the viewpoints of fundamental solid-state physics, solid-state chemistry and technological applications. We found that Ar^{+}-irradiated, metallic $SrTiO_3$ crystal emits 430-nm blue-light at room temperature. The oxygen-deficient metallic $SrTiO_3$ thin films grown under low-oxygen pressure also show the blue-light emission. Therefore we concluded that the Ar+-irradiation introduces oxygen deficiencies in the crystal surface, and that the deficiencies generate conduction carriers and play an important role in the emission. A model by which the doped conduction electrons and the exited holes in the in-gap state produce a new radiative process that emits blue light is proposed. It is emphasized that the emitting region could be patterned into any size and shape by the local engineering of the oxygen-deficiency in $SrTiO_3$. Shown in Fig.1 are examples of patterned blue-light emission in the form of "KYOTO". By combining conventional photolithography and Ar^{+}-milling (irradiation), locally oxygen-deficient regions in positive and negative manners are fabricated on the stoichiometric $SrTiO_3$ substrates. In the upper panel of the figure, only the irradiated KYOTO shines in blue, whereas in the bottom panel, the non-irradiated KYOTO remains dark. This is a clear demonstration of simple method for the room-temperature blue-luminescence on macroscopic and microscopic scales. These new features of $SrTiO_3$ will open up new possibilities for the oxide-base electronic devices.

Figure 1. An example of the blue-light emission from a local engineered region of oxygen vacancies in $SrTiO_3$.

Size-Controlled Synthesis of Monodisperse Spherical V_2O_5 Particles

We developed a method to synthesize monodisperse spherical V_2O_5 particles with various sizes via hydrolysis of vanadium isopropoxide in acetone/pyridine mixture solution under air. In Fig.2, their average size (D) and the standard deviation (σ) are plotted against the concentration of pyridine (C). Fig.3 clearly shows that the size and its distribution are strongly dependent on C. At low C ($C < 2.5$ wt%), they are small and rather polydisperse. However, at higher C ($C > 2.5$ wt%), the situation drastically changes. They become monodisperse, their size distribution being as low as ca. 7%. It is worthwhile to note that the size of them can be controlled from about 200 to 800 nm by changing the concentration of pyridine while keeping their narrow size distribution. Such monodisperse V_2O_5 particles are possibly used in catalysis, lithium ion battery, electrochromic device, sensors and actuators.

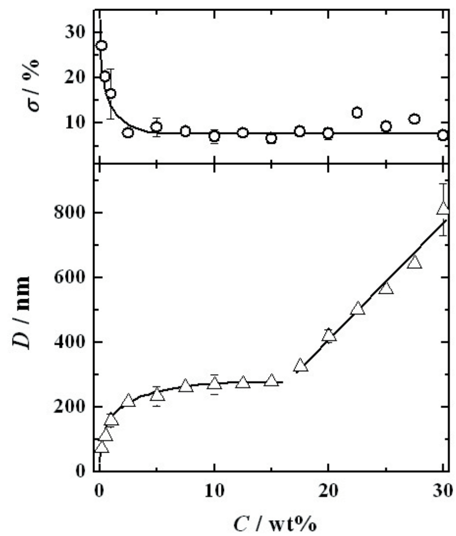

Figure 2. Plots of D (open triangles) and σ (open circles) as a function of C. Solid lines are guide to eyes.

tion Metal Oxides and Development of Single Crystal Growth Technique Using High Pressure Method, The Japan Society of High Pressure Science and Technology, 30 October 2005.